Surface Magnetic and Electronic Properties of Layered Manganite Single Crystals

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Transmission of information using the spin of the electron as well as its charge requires a high degree of spin polarization at surfaces. At surfaces however this degree of polarization can be quenched by competing interactions. Using a combination of surface sensitive x-ray and tunneling probes, we show for the quasi-two-dimensional *bilayer* manganites that the outermost Mn-O bilayer, *alone*, is affected: it is a 1-nm thick insulator that exhibits no long-range ferromagnetic order while the next bilayer displays the full spin polarization of the bulk. Such an abrupt localization of the surface effects is due to the two-dimensional nature of the layered manganite while the loss of ferromagnetism is attributed to weakened double exchange in the reconstructed surface bilayer and a resultant antiferromagnetic phase. The creation of a well-defined surface insulator demonstrates the ability to naturally self-assemble two of the most demanding components of an ideal magnetic tunnel junction.

High spin polarization at surfaces and interfaces is a key component for transport of information using the spin degree of freedom of the electron. Unfortunately, the physics and chemistry of surfaces can reduce this spin polarization through chemical inhomogeneity, strain or surface reconstruction. Many half-metallic ferromagnetic oxides exhibit very high bulk magnetization, but the spin polarization at surfaces and interfaces declines more rapidly than the bulk magnetization as the Curie temperature, T_C, is approached. Magnetic tunnel junctions as well as other probes of surface polarization in perovskite-based manganites indicate the presence of a non-ferromagnetic surface region, often called a “dead layer,” of thickness ~5 nm.

We show for the quasi-two-dimensional *bilayer* manganites that the outermost Mn-O bilayer, *alone*, is affected: this 1-nm thick intrinsic nanoskin is an insulator with no long-range ferromagnetic order while the next bilayer displays the full spin polarization of the bulk. This unexpectedly abrupt termination is likely due to the reduced dimensionality of the crystal structure. That is, the electronic and magnetic coupling between the bilayers is markedly weaker than the corresponding *intra*bilayer couplings or the isotropic couplings found in non-layered ferromagnetic oxides.

This research provides a nice example of the power of coupling synchrotron x-rays with other techniques to address complex science issues.